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Lengwiler, Martin

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# Risky Calculations: Financial Mathematics and Securitization since the 1970s

Martin Lengwiler\*

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**Abstract:** *»Risikokalkulationen: Finanzmathematik und Verbriefung seit den 1970ern«.* The article investigates the history of securitization in order to analyze more general transformations in the social and political approaches towards various types of credit risks. The history of securitization reveals a long-term shift in the conventions addressed when dealing with risks. Socio-political conventions were gradually replaced by financialized, market-oriented conventions in which investors would take responsibilities and replace other actors, like the state or private corporations, which were previously involved. The first part of the article examines the epistemic and economic origins of securitization. In the second part, the analysis focuses on the golden age of securitization, from the 1980s to the mid-2000s, discussing decisive factors for its expansion. The third part reflects the role of securitization in the financial crisis of 2007/08 and debates the extent to which mathematical expertise can be made responsible for the collapsing securities market.

**Keywords:** Securitization, financialization, quantification, financial markets, financial mathematics, insurance, risk, conventions.

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## 1. Introduction<sup>1</sup>

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The increased social relevance of economic values and market-based interactions over the past decades – not least since the financial crises of 2001 and 2007/08 – has provoked a growing interest, within social sciences and historiography, in economic issues beyond the traditional fields of economics and economic history. In recent years, several authors, by combining approaches from sociology, anthropology, institutional theory, and the history and sociology of science and technology, pointed to the social conditions, conventions, and implications of economic practices and market-related interactions. One field of research is represented by studies on the relation between economics and the economy – more precisely on the epistemic and technical conditions of financial markets, such as the role of theoretical models and technical systems for

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\* Martin Lengwiler, Department of History, University of Basel, Hirschgässlein 21, 4051 Basel, Switzerland; martin.lengwiler@unibas.ch.

<sup>1</sup> This article is dedicated to the memory of Stefan Beck (1960–2015).

the performance of markets, or the relation between modern finance theory and transformations of investment practices in financial markets. Alain Desrosière's work on the co-constitution of statistics, economics, and the modern state has provided an ongoing stimulus for these critical studies of financial markets (seminal: Desrosières 2008a, 2008b; Callon 1998; see also: Orléan 2014; Beckert, Diaz-Bone and Ganßmann 2007; for an exemplary case study: MacKenzie 2006). A second area of research focuses on the transfer and adoption of economic logics and practices to social contexts outside their traditional field (for a historical perspective: Mass 2016).

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## 2. Securitization from the Perspective of the Sociology of Conventions

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This article investigates a specific type of financial transactions: the process of securitization of credit risks that is the transformation of financial risks into investment products in order to sell them on the financial market. This financial instrument has massively expanded since the 1970s and has infiltrated crucial parts of the financial sector. Securitization gained much prominence in the 1990s and 2000s, and was made responsible – at least partially – for the outbreak of the financial crisis in 2007/08. It has continued to spread after the recent recovery of the markets. Securitization has the potential – as will be argued below – for transforming social and political attitudes to risk, and introducing and diffusing changing forms of ownership and responsibilities towards risks. The trend towards securitization is not only relevant for a changed understanding of risk. By using highly mathematized investment products, it also offers an exemplary case to analyze the relevance of processes of quantification for the diffusion of financial values and techniques.

On a theoretical level, the article is based on the sociology of conventions. For several reasons, this approach offers a promising analytical tool for studying financial markets. It combines the study of institutions – here: financial markets – with a pragmatic, actor-centered focus on the conventions used by actors – the modes of justification or reasoning (Diaz-Bone 2011, 23 et seq.). Moreover, the sociology of conventions is based upon the idea that economics and markets are socially embedded. In light of constructivist approaches, not least of Desrosière's analysis of the "politics of large numbers" and the role of conventions of equivalence – technical norms, measurements and standards – in the formation of modern nation-states, the sociology of convention shifted the focus from the state to the economy and the market, where similar epistemic processes are at work (Diaz-Bone 2015, 291-320). The types of conventional frameworks are defined in an open, flexible, and empirically grounded way, distinguishing a plurality of modes, such as industrial, market-related, family-based, civic, or welfare-related conventions (Diaz-Bone 2011, 23 et seq.; Diaz-

Bone and Salais 2011). This flexible understanding of conventions makes the concept highly appropriate to understanding the transformations of values involved in securitization.

In line with this theoretical tradition, Eve Chiapello recently introduced the concept of financialization in order to understand the changing forms of valuation in the financial sector and in other parts of society.<sup>2</sup> Financialization means, according to Chiapello, a process with which financialized valuations and conventions expand and colonize other political, social, or cultural practices. Financialized conventions are marked by approaches from the disciplines of financial economics and mathematical finance – academic fields dedicated to studying, with highly formalized and quantified models, the mechanisms of financial markets, in particular the calculation of prices and values. In this sense, financialization is understood as a particular – and particularly influential – form of economization, marked by a high degree of mathematization and quantification. That process is also seen as a key aspect of recent transformations of capitalism (Chiapello 2015, 13-7). Also drawing on the sociology of conventions, André Orléan argued that the formal and mathematical conventions of economics were exemplary practices for the emerging financialized capitalism. They acted as normative claims and thus created the specific forms of financialization. The recent crisis of financial markets is for Orléan also a crisis of the epistemic basis of economics. By criticizing rational choice paradigms, he calls for a more sociological understanding of the concept of value (Orléan 2014, 259-71, 311-21).

Securitization is clearly one of the more prominent and exemplary business fields related to the process of financialization as understood by Chiapello or Orléan. Here too, quantification is a key issue. The construction and calculation of securities in this context is linked to highly sophisticated mathematical and actuarial models. The process of securitization thus operates by quantifying assessments about credit risks, defining a price based on these calculations, and selling the risks – in a repackaged form – as securities to investors. Against this background, the article also asks about the conditions and effects of processes of quantification in the context of securitization, drawing on the pertinent literature on the social and cultural implications of calculation and quantification (Porter 1995; Callon 1998, 6-12; Lampland and Star 2008; Desrosières 2008a, 2008b). What role does scientific expertise – in particular mathematics and actuarial theory (the insurance-related sub-discipline of mathematics) – play in the process of securitization? To what degree did these “conventions of equivalence” (Desrosières) accelerate the trend towards securitization? How important were mathematical models for legitimating innovative investment products, given that quantification is generally understood as a “technology of

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<sup>2</sup> See also the contribution of Chiapello and Walter in this HSR Special Issue.

trust” (Porter 1995)? And to what degree were mathematicians and actuaries responsible for the failure of securitization in the context of the crisis of 2007/08?

What exactly is meant by securitization? The concept, used since the late 1970s, refers to a relatively new instrument for transforming financial risks – usually credit risks – into securities, that is, into investment products to be sold to investors, either directly or via financial markets (Gorvett 1999, 138-40; Kothari 2014). Securitization, as a technique to turn rights to future cash flows into tradable securities, emerged in the 1970s and played a controversial role in the financial crisis of 2007/08. The products of securitization belong to the category of structured investment products, themselves being a subcategory of the large variety of derivatives. Securitization thus became infamous for some of the notoriously opaque forms of investment vehicles, in particular for the families of asset-backed securities (ABS) and mortgage-backed securities (MBS). In retrospect, securitization is thus seen as a crucial factor for the quick spread of financial risks after the collapse of the U.S. market for subprime mortgages in 2007, leading directly to the liquidity crisis of the U.S. and international banking system in the following year (Lybeck 2011, 141-70; Cox, Fairchild and Pedersen 2000, 158).

But securitization is more than just an element of the financial crisis of 2007/08. The technique established itself in the banking and insurance industry long beforehand and independent from the immediate pre-history of the crisis. Moreover, many actors in the financial industry grant securitization the potential of transforming the industry as a whole. It is still debated – and will be analyzed in this article – whether securitization marks a structural shift in banking and insurance, transforming the way financial institutions and societies deal with credit and other social and natural risks. Thus, the article also addresses the question of how much securitization transformed the social responsibilities towards risks and the related mechanisms of solidarity. To what degree are risks, previously seen as a social or political issue, currently being treated as part of the mechanisms of financial markets?

The rise and spread of securitization was fueled by two factors. The basic conditions were laid down in the 1950s by epistemic innovations in economics and actuarial science, in particular the development of mathematical models for option pricing and other price mechanisms on the financial markets. The other factor is constituted by the drastically increased demand for innovative financial products which emerged in the 1980s, and has ever since driven the trend towards securitization.

Both factors are related: Mathematical expertise was an important condition for the legitimacy and the reputation of securitization, as illustrated by the positive ratings for asset-backed securities by the major credit rating agencies. And the expanding demand for products of securitization led to a quickly growing market, which reinforced epistemic processes by attracting parts of the

mathematical community and strengthening the new field of mathematical finance. These interactions shall be analyzed, together with their range and social implications, in this article. The argument is structured in three parts. The first part examines the origins of securitization – both on the epistemic and the economic level. The second part analyzes the golden age of securitization, from the 1980s to the mid-2000s, pointing at the decisive factors for its expansion. The third part investigates the role of securitization in the financial crisis of 2007/08 – in particular the debate to what extent mathematical expertise was responsible for the collapsing market for securities. It also looks at the recovery of securitization since the peak of the crisis, discussing the reasons for its resilience. The conclusion summarizes the fundamental changes, provoked by the rise of securitization, in the social responsibilities towards the concerned risks.

The article is marked by a special interest in the specific, historically important area of securitization in insurance. Insurance is indeed an exemplary field for the history of securitization. As a technique against the risk of financial losses, securitization gained particular prominence in insurance from early on, especially in reinsurance. Today, securitization is seen as a prominent form of an alternative risk transfer. Risk transfers lie at the heart of the reinsurance business. In their common form, they consist of distributing the risks between the insurer and the reinsurer, as specified in the reinsurance contract. If an insurer chooses some alternative risk transfer, it usually means that the insurer tries to bypass the common deals with reinsurance companies. Insurance related securitization implies that the insurer, instead of going to a reinsurance company, turns its risk into an investment vehicle. Although securitization is usually more expensive than reinsurance, primary insurers still use it as a more efficient allocation of risks, especially in cases with the risk of huge losses (where reinsurance is often unavailable) or in areas where long-term guarantees are needed (given that reinsurance contracts are usually short-termed, often just for a one-year delay; Cox, Fairchild and Pedersen 2000, 158, 184). In certain fields of the insurance market, like the insurance of natural catastrophes, securitization established itself as respected alternative to reinsurance, with a current market share of about 10 per cent (Swiss Re 2013; Philips 2014).

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### 3. The Origins of Securitization: Emergence of Mathematical Finance and Booming Demand for Investment Products

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The mathematical foundations for securitization stretch back into the 1950s and are closely linked to the growing influence of mathematical approaches in economics, in particular to the emergence of the field of mathematical finance (Bühlmann and Lengwiler 2015). Before that, mathematicians and actuaries

considered financial markets too complex for mathematical analysis. The lack of tools, like the computer, for calculating highly complex data strengthened this conviction. The analysis of financial markets by econometricians was limited to analyzing the economic role of interest, in particular to calculating interest rate term structures (the calculation on the dependency of market interest rates on the time to maturity; Nitzsche 2012; Aase 2012).

In the 1950s, economists increasingly began to adopt mathematical approaches for their models. Figures such as Kenneth Arrow and Gérard Debreu revived the concept of a general economic equilibrium, classically defined by Léon Walras in the 1870s. Arrow had already tried to use the idea of complete markets (a market with full transparency and no transaction costs) in order to mathematically calculate the price of securities (Arrow 1951; Debreu 1959). These models were already based on the theoretical assumption of no-arbitrage, according to which markets are complete, transaction costs nonexistent, and prices set in complete transparency. The breakthrough for the calculation of market-based price mechanisms came in the early 1970s with the design of a model for option pricing, based on the principle of no-arbitrage, by Fischer Black, Myron Scholes and – independently – by Robert C. Merton (Black and Scholes 1973; Merton 1973). The Black-Scholes model allowed for the calculation of specific forms of option trading at stock exchanges and opened the door to a wide range of applications. It became an important factor for the boom of derivative markets in the 1980s, especially at the Chicago Board Options Exchange (CBOE), an exchange installed by the Chicago Board of Trade in 1973. The seminal works of Black, Scholes, and Merton also marked a crystallizing moment for the development of mathematical finance, a new and immensely successful combination of economics, applied mathematics and – partly – actuarial science (for a detailed account of the emergence of financial economics: MacKenzie 2006, 119-78; see also MacKenzie 2007).

In actuarial science, the emergence of mathematical finance prepared the ground for the foundation of a sub-section of the International Actuarial Association (IAA) in 1988 – only the second sub-section in the IAA's history – dedicated to the "Actuarial Approach for Financial Risks" (AFIR). The foundation of AFIR was marked by a controversial debate within the IAA on the relevance of financial markets as a topic for actuarial research (Bühlmann and Lengwiler 2015; Bühlmann 1987). But since the 1990s, the field of mathematical finance has firmly established itself at the crossroads of economics and actuarial science. Today, it is widely accepted that mathematical finance has the potential of transforming traditional approaches of actuarial theory, for example in the understanding of risks of financial markets and the calculation of reserves invested at the financial markets (Bühlmann 1998; Bühlmann and Lengwiler 2015).

Apart from this epistemic factor, the emergence of securitization also profited from the stock market boom, especially from the expansion of the market

for derivatives, fueled by the increased demand of investors since the 1980s (Cassis 2010, 248-55). In its current form, securitization was first used on the U.S. mortgage market in a social-political logic. In the mid-1970s, after the recession of 1973/74, the U.S. government tried to counter the mortgage and credit restrictions of the U.S. banking system by creating a secondary market for mortgages based on government guarantees for mortgage loans and provided by government agencies like Fannie Mae, Ginnie Mae, and Freddie Mac (Cassis 2010, 252 et seq.; Hill 1996). The socio-political side of it was that securitization was meant to make mortgages more affordable for the lower-middle classes, especially in the context of the credit crunch, widespread in the late 1970s as banks restricted the availability of credits. Securitization proved to be an important element in improving the financial stability of the government-sponsored mortgage agencies. Already in 1968, the Johnson administration created the “Federal Home Loan Mortgage Corporation” (“Freddie Mac”), a private organization for sponsoring home ownership, which joined its sister agencies “Ginnie Mae” (“Government National Mortgage Association”), and “Fannie Mae” (“Federal National Mortgage Administration”), two organizations with origins stretching back to New Deal legislation of 1938. Ginnie Mae and Fannie Mae were originally designated for government employees and veterans. Since 1970, Fannie Mae and Freddie Mac were allowed not only to buy mortgages on the secondary market, but also to pool them and sell them as mortgage-backed securities; Fannie Mae sold the securities to the government owned Ginnie Mae, Freddie Mac sold them to the financial market. As all three organizations profited from a de facto government guarantee, investors were keen to buy the papers (Lybeck 2011, 120-9, 141; Geisst 2013, 225-9; Hill 1996, 1064-76, 1119-21).

Also in the 1970s, the banking sector began to adopt the new instrument. Banks first used securitization for their mortgage business, following the example of the government sponsored mortgage agencies. The practice spread especially in niches of the mortgage market, for example for lower quality mortgages or large mortgages. Bank of America introduced securitization in 1977, in particular to raise its capital basis and to be able to meet the growing demand for mortgages. Securitization expanded in the 1980s, when it was taken up by a variety of financial institutes, for securities based on credit card debts, auto loans, and other assets (Hill 1996, 1120 et seq.; Gorvett 1999, 138-40; Cowley and Cummins 2005, 194 et seq.). Between the 1980s and the 2007 crisis, securitization became a widespread phenomenon in investment banking. In the U.S. market just before 2007, mortgage- or asset-backed securities represented nearly one third of all banking assets, amounting to nearly 3,000 billion dollars (De Mey 2007, 37). By 2007, the subprime mortgage sector, in which securitization was widespread, represented 12 per cent of the U.S. mortgage market (Lybeck 2011, 127-9). All sectors contributed to this growth: mortgage-backed securities, insurance-backed securities, as well as those backed by car



loans, credit card debts, or student loans (Cummins 2004, 7 et seq., 48). The popularity of securitization is illustrated by the fact that the technique even spread to the entertainment industry in the form of “celebrity bonds.” As one of the first artists, David Bowie used securitization in 1997 to raise 55 million dollars, backed by the royalties of his past albums (Fabozzi and Kothari 2008, 3).

The expansion of securitization was combined with a redefinition of its logic. Whereas in the 1970s, securitization was embedded in a social policy framework (to make mortgages more accessible), in the 1980s and 1990s it gradually became a financial instrument to improve corporate profits and appease the appetite of investors for profitable investment products. The rise of securitization to an exemplary practice of a financialized capitalism and its redefinition from a socio-political to a financialized convention can be explained by three factors.

First, securitization profited from a general deregulation of the financial sector since the 1980s – in the U.S. as well as in the European Union. The market was opened for new competitors, whereas traditional corporations – banks and insurances – also expanded their business activities. As an effect of this, banks increasingly had to compete with money market funds, mutual funds, life insurance companies, and other financial service providers. This was paralleled by a wave of corporate mergers and the launch of new financial products. In this context, securitization was used as an instrument to improve the competitiveness of financial institutions, not least by reducing credit risks and thus increasing the capital basis, liquidity, and credit ratings of the respective companies (Orléan 2014, 264-71; Cummins 2004, 2, 15-21; Hill 1997, 1122-5).

A second factor was supportive government legislation, especially in the U.S. In the 1980s, U.S. tax regulation was reformed to offer tax advantages for the new investment products (Hill 1996, 1120 et seq.). A third – and probably the most important – factor for the spread of securitization was the rapidly growing demand of investors for new financial products. This was partly an effect of a structural change in the banking business: the rise of investment banking and the relative decline of commercial banking. That trend gained momentum since the 1970s and led to a proliferation of financial products, among them also derivatives like the products of securitization. During the stock market boom of the 1980s, investors not only asked for traditional products but also took up the quickly developing range of derivatives, in particular those that did not follow the cyclical performance of traditional stocks and bonds. Securitized products often had an acyclical or an anticyclical performance, which allowed investors to diversify their portfolio and hedge against high levels of risks in their portfolio or generally against the risk of a cyclical development of stock markets. In this sense, securitization has been called a “low-cost sweetener for lemons” (“lemons” being poor investments; Hill 1999; see also: Cassis 2010, 243-53; Cummins 2004, 13).

Whereas in banking, securitization mirrors the attempt of financial institutions to improve their profitability as well as the increased demand for innovative investment products, the interest of insurance corporations had a different background. The market for insurance-linked securities also expanded on a lower level than the one in banking. Just before the 2007 crisis, the total amount of securitized risks in insurance was 10 billion dollars (compared to 3,000 billion dollars in mortgage- and asset-backed securities; De Mey 2007, 37, see also: Cummins 2004, 7 et seq., 48). Between the 1980s and 2007, 35 billion dollars of insurance liabilities have been securitized. The total of securitized assets is worth less than a thousandth of all reinsurance liabilities (figures of 2007, Baig and Choudhry 2013, 24-7). In insurance, securitization remained a technique for niche markets. It is mainly used for large risks, such as catastrophe risks, where it gained a prominent role. In reinsurance, for example, the extent of securitization amounted to 11 per cent of its non-life premium income in 2004 (De Mey 2007, 37).

Nevertheless, the case of insurance-related securitization is relevant because it can help to illuminate not yet mentioned factors and implications of the history of securitization. It shows that a traditionally risk-averse industry – at least in its use of capital reserves during the decades after the Second World War – started to open itself to more speculative policies since the 1980s. This was a direct consequence of the stock market boom of the 1980s. At that time, insurance companies realized that investing their reserves in stocks and bonds increased their profits, and that their earnings were increasingly linked to the development of capital markets. Some corporations earned their profits more so from investments in capital markets than from their traditional insurance business (Bühlmann and Lengwiler 2015).

This trend was followed, in the 1990s, by a structural transformation of the insurance business as a whole: its increasing integration with the banking business under the term of “bancassurance.” The trend is mirrored by a series of mergers between banks and insurance companies. Examples are the merger between Citicorp (a bank) and Travelers (an insurer) to Citigroup (1998), or the take-over of Winterthur (an insurer) by Credit Suisse in 1997. Bancassurance fueled the development of combining banking and insurance products, delivered by one and the same company, and increased the technical cooperation between insurance actuaries and business economists for developing investment products and modelling insurance and investment risks (Bühlmann and Lengwiler 2015; Cummins 2004, 15-21). As a business model, bancassurance did not prevail and was abandoned after the crisis of 2001. Still, many forms of cooperation between insurance and banking remained, not least in the development of investment products.

This was the fertile ground on which insurance-related securitization emerged in the late 1980s. The first insurers to deviate from the established way were companies trying to avoid the common procedures and costs of rein-

insurance. Though reinsurance can offer less expensive contracts than the comparable costs for securitization, it has also, as mentioned above, important disadvantages when compared to coverage over financial markets. Reinsurance contracts are usually short-termed, often with a contract period of just one year. Moreover, some unconventional or excessive risks were usually not covered by reinsurance. In these cases, securitization offered an alternative with fewer transaction costs, mainly because capital markets were able to mobilize far more capital and in a more flexible way than insurance or reinsurance companies (Cummins 2009, 466, 475; Cox, Fairchild and Pedersen 2000). The capital basis of the reinsurance sector (estimated at around 300 billion dollars) is still a dwarf – around 300 times smaller – against the dimensions of the financial markets (estimated at over 100 trillion dollars; Hewitt EnnisKnupp 2014, 2).

Thus, insurance-based securitization became an instrument to mobilize capital for over-sized, catastrophic risks like windstorms or earthquakes. American life insurance corporations started the securitization of their insured liabilities in 1988. An important step was made when, in 1992, the Chicago Board of Trade, the leading stock exchange for futures, options, and derivatives, accepted the first “catastrophe bond,” a security based on catastrophic property risks (Cummins 2004, 2). Around half of these bonds were addressed specifically to extraordinary, “once in a century” events. The category of Cat bonds became the motor for the development of securitization in insurance. The 1990s and the early 2000s witnessed a boom of securitization in insurance, spurred by a series of catastrophic events with excessive losses for the insurance and reinsurance industry, such as hurricane Andrew (1992), the Northridge earthquake (1994), the attack on the World Trade Center (2001), and hurricanes Katrina, Rita, and Wilma (all in 2005; De Mey 2007, 37-42; Cummins 2004, 2009, 463 et seq.). Another driving force was – similar to securitization in banking – the rising regulatory demands, in particular for capital reserves, in the aftermath of Basel I (1988), during negotiations of Basel II (which started in 1999 and were concluded in 2004), and in the context of the European Union solvency prescriptions for the insurance industry (Solvency I, 2002; Lybeck 2011, 230-5; Cummins 2004, 13; 2009, 482-8).

Last but not least, securitization also expanded as part of corporate policies for tax evasion. Many corporations, among them Swiss Re, founded so-called “captives” – sub-companies for covering particularly high risks, mainly domiciled in tax-saving offshore places like Bermuda – for their securitization business (Cox, Fairchild and Pedersen 2000, 166-168).

The insurance corporations active in securitization included some of the leading companies. One of the first movers was AIG (“American International Group”), an American insurance company, which earned a reputation for aggressively entering the new securities market. AIG launched in 1992 the first cat bond due to cover against wind and earthquake risks. In 2008, it had to be saved by a government loan, becoming the largest victim in the insurance sec-

tor of the crisis (Shelp and Ehrbar 2009; Greenberg and Cunningham 2013). The US company USAA and the French AXA also belonged to the pioneers in securitization (AXA for its car insurance branch, USAA rather for Cat bonds), as well as Zurich Financial Services and Winterthur (De Mey 2007, 38; Wemmer 2008, 1 et seq.; Cox, Fairchild and Pedersen 2000, 159, 165-7).

Reinsurance companies found themselves in a difficult situation. The reinsurance industry was split over how to deal with securitization. Some companies avoided the securities market as they saw it as an alternative and a competition to their core business. Others entered the new market in an attempt not to miss out on a structural transformation of their business. Some of the leading reinsurers, most notably Swiss Re and St. Paul Re, decided for the second option – at the beginning reluctantly – and became important promoters of securitization by the end of the 1990s (De Mey 2007, 38; Wemmer 2008, 1 et seq.; Cummins 2009, 464; Cox, Fairchild and Pedersen 2000, 159; Bühlmann and Lengwiler 2015).

Although the life insurance market played a minor role in insurance-related securitization, it was not untouched by the trend (Cowley and Cummins 2005). Such securities were primarily based on mortality and longevity risks. Technically, these bonds were based on mortality or longevity indexes, constructed by experts. The profit for the investor depended on whether or not the observed mortality or longevity rate exceeded the assumption calculated by the index (Cipra 2010, 549-52; De Mey 2007, 38). Longevity bonds in particular are seen as an innovative and promising field for securitization, though they are also known to be notoriously difficult to calculate. The number of unsuccessful securities is comparably high (De Mey 2007, 39 et seq.). The first companies to enter this field were American Skandia and Hannover Re – already in the late 1990s – followed by a series of life insurers and reinsurers, such as AIG, Prudential, MONY, Barclays Life, AXA, Swiss Re, Scottish Re, and Munich Re. Banking houses like the European Investment Bank and BNP Paribas also contributed to this quickly growing market (Cipra 2010, 549-53; De Mey 2007, 38 et seq.; Cox, Fairchild and Pedersen 2000, 163; for detailed lists of companies and bonds: Cowley and Cummins 2005, 209; Larson 2012, 8 et seq.).

The growing interest in life insurance securitization is also due to the extraordinary social and political significance of this sector. Mortality and longevity rates are affecting not only life insurance, but also the pension system in general. Pension funds – in private and social insurance – do not have many instruments to safeguard their business against the rising life expectancy. It is no coincidence that calls for securitization were also embedded in socio-political conventions, for example in the case of the OECD, which called to improve the instruments to securitize against longevity, not least as a policy to act against the demographic pressure on public and private pension systems

(De Mey 2007, 38).<sup>3</sup> Business economists too argued for a quick development of life insurance securitization, also for socio-political reasons (Lorson 2012, 2 et seq.). The topic has recently attracted much scholarship. Most studies focus on how to define an appropriate price for securities based on longevity and mortality risks (Lorson and Wagner 2012; Lin and Cox 2005, 227-52). In all these debates, implicitly or explicitly, the responsibility of the state for providing social security for the elderly gradually shifted to the financial market and the community of profit-oriented investors. Here too, the conventions addressed by actors like the state, changed from a socio-political to a financialized context.

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#### 4. The Mathematical Basis of Securitization and the Mathematicians' Role in the 2007 Crisis

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As mentioned at the beginning, securitization was a crucial factor in the financial crisis of 2007/08, especially in the context of the subprime crisis of the U.S. mortgage market. Current assessments of the crisis argue that there is not one single factor, but a complex cluster of factors causing the breakdown. These include: the extremely low interest rates since 2001, lenient lending practices in the markets for subprime mortgages, a shadow banking system with high leverage investments, questionable accounting practices, and misjudgments of rating agencies. The collapse of parts of the U.S. mortgage market triggered several other crises: the banking crisis in the U.S. and in European countries, and – indirectly – a budgetary and sovereign debt crisis of several European countries, followed by the currency crisis of the Euro (Lybeck 2011; Baig and Choudhry 2013, 26-9; Senate Subcommittee on Investigations 2011; Reinhart and Rogoff 2009; Kobrak and Wilkins 2013).

Securitization was involved because the subprime loan market and parts of the derivative market were backed to a large degree by complex and intransparent securities. When the U.S. Federal Reserve started to raise interest rates in 2004/05 in order to act against the rising inflation, many lenders of subprime mortgages had to default. In 2007, the subprime market quickly collapsed, and several structured products, in particular mortgage-backed securities and credit default swaps, lost their previous value. Although the market for insurance-linked securities suffered less than that for other securities, insurance and reinsurance companies still took severe losses from their engagement in securitization. After the collapse of Lehman Brothers – an investment bank intensely engaged in the securitization business – markets for mortgage- and asset-

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<sup>3</sup> See also <<http://www.artemis.bm/blog/2014/12/09/oecd-calls-for-capital-markets-to-embrace-longevity-risk-hedging>> (Accessed July 20, 2015).

backed securities also collapsed. AIG – one of the market leaders – had to be saved by a government bailout. Fannie Mac and Freddie Mac also only survived after massive government interventions. Other banking and insurance corporations also suffered; Swiss Re for example wrote down its portfolio by more than 1 billion dollars (Lybeck 2011, 112-8, 145-62; Kindleberger and Aliber 2011, 257-72; James et al. 2013, 349 et seq.; Cummins 2009, 485; Shelp and Ehrbar 2009; Lengwiler 2012, 164 et seq.). Some measures against the crisis proved counter-productive. At the beginning of the crisis in 2007 and 2008, asset-backed securities were accepted by central banks as securities for the balance sheets of banking institutions – a decision that fueled the spread of securitization in the midst of the crisis (Baig and Choudhry 2013, 28).

In relation to securitization, the crisis of 2007 raises two questions. First, it challenges the seemingly sound mathematical basis of the products of securitization, provoking a debate about the technical solidity of securitization. Second, as securitization was deeply entangled with the escalation of the crisis, the economic downturn provoked fundamental criticisms against securitization itself (Orléan 2014, 259-71). Both criticisms will be discussed in the following paragraphs and illustrated with the exemplary case of insurance-related securitization.

First to the question to what extent the mathematical basis of securitization was to be blamed for its failure in the financial crisis since 2007. The question also points to the possible responsibility of mathematicians and actuaries involved in the construction of securitized investment products for the aggravation of the crisis. It is undisputed that actuaries and mathematicians had a say in the design and the implementation of processes of securitization. The whole expansion of the market for derivatives was partly based on the possibility of mathematically calculating an adequate pricing of options based on the Black-Scholes-Merton models mentioned above (MacKenzie 2006, 143-84). In this context, insurance and reinsurance actuaries often acted as experts on catastrophic and other risks, and provided the calculation of the necessary indices for the construction of securities. They did this not just for their own companies, but also as consultants for commercial banks and other bond issuers. In the insurance sector, the policy of securitization was promoted mainly by actuaries, which saw in the new market a potential for their companies' business. In the banking sector, securitization was mainly promoted by managers and business economists, while actuaries – at least at the beginning of the process – only played a marginal role (Bühlmann and Lengwiler 2015).

It is also worth noting that the actuarial community, up to the outbreak of the crisis, remained split about securitization. The major part of the actuarial profession remained skeptical, whereas a small but influential minority embraced the new technique as a way of diversifying insured risks. At least the launch of Cat bonds in the 1990s apparently happened without much defining influence of the actuarial profession. Actuaries were mainly providers of data

(loss indices) for the construction of securities, whereas the construction and pricing of securities was executed by accountants and business economists (Bühlmann and Lengwiler 2015). Thus, some observers, as late as 2000, noted that, due to the marginal status of actuaries in securitization, the mathematization of the process, at least in insurance-related securitization, was not very developed at all, and that a lot of theoretical work still had to be done, for example on risk measurement and adequate pricing of securities (Cox, Fairchild and Pedersen 2000, 158). Despite these obstacles and reservations, the influence of mathematicians and actuaries had been gradually growing since the 1990s, and some important figures of the actuarial community were involved in the design of insurance-related securities, for example James Tilley (\*1950) who worked for Morgan Stanley (at that time one of the leading U.S. investment banks) on the construction of Cat bonds, or Prakash A. Shimpi, who until 2004 worked for Swiss Re in senior management positions and lead a subsidiary of Swiss Re dedicated to trading insurance risks (Cox, Fairchild and Pedersen 2000, 185).

Against this background, there is no doubt about the active and decisive engagement of at least part of the actuarial community in policies of securitization. The more important issue is whether their work – the mathematical formulae upon which securitization was based – can be blamed for the collapse of the market for asset-backed securities. There is no clear answer to this question. The literature takes two opposite positions.

The more critical perspective insists that mathematicians and actuaries were responsible as one of several involved actors for the collapse of the market for securitization and for the respective parts of the crisis. Mathematicians and actuaries at least tolerated structured products being constructed in an intransparent and far too complex way. These critical voices argue that mathematical finance might be good in the construction of theories while conceding that the reality of the financial markets had nothing in common with the theoretical assumptions. Markets cannot be modeled – according to this criticism – as a perfect and efficient entity. The related no-arbitrage theory is also criticized for lacking any empirical ground and helping to confuse theory and reality so that investors assumed that the models were built after objective statements, whereas they merely reflected theoretical assumptions. Another problem is seen in the strong and effective alliance between mathematics and economics. Economists referred to mathematical expertise in order to provide an aura of objectivity and trustworthiness for their investment products, and mathematicians were eager to help economists because financial markets provided a promising and highly prestigious field of application for their theorizing (MacKenzie 2006, 243-60; Bieta and Milde 2014a, 2014b).

Authors who avoid blaming mathematicians for the crisis argue that the work of mathematicians and actuaries was mainly a theoretical endeavor and not meant to give a clear, objective assessment of the dynamics of financial markets. They

make a sharp differentiation between the model and the reality of financial markets. The models mathematicians built were meant as regulative ideas with heuristic value – in order to get a rough, approximate understanding of the real world –, but not as objective descriptions with a prognostic value. Models are seen as full of insecurities, not to be held for eternal truths. These authors deem it unfair to put the blame on the mathematicians when the fault actually lies with the public and its misunderstanding of the validity of mathematical models (Schweizer, Soner and Teichmann 2015; Bühlmann 1998). Some economists and actuaries even argue that it was unavoidable that securitization included a certain lack of transparency. Relying on a perfect market model and on the principle of no-arbitrage, they argue that lack of transparency and asymmetries of information are inherent elements of financial markets, not least offering the necessary incentives for securitization. A complete market with full information transparency and no transaction costs – a situation of no-arbitrage – would not offer a price for the repackaging of risks in the form of securities, and therefore no profits for securitization. Only if markets became more efficient would the incentives for securitization decrease (Cummins 2004, 9-14; Cox, Fairchild and Pedersen 2000, 158; Hill 1996, 1101-5).

This defending argument is not denying the involvement of mathematicians and actuaries in securitization. Rather, it asserts that their influence has not been strong enough to prevent false conclusions of their calculations and an exaggerated belief of the public in the solidity of their assessments. Actuarial figures retrospectively stress that the market was driven by management decisions and by investors' demand, whereas the warnings of actuaries and mathematicians were mainly overheard. Actuarial scientists like Hans Föllmer, Catherine Donnelly, or Paul Embrechts argue that the collapse of the market for derivative products rather depended on the application of actuarial assessments – beyond the reasoning of the involved actuaries – and the questionable business practices of securitization like the lack of corporate control, fraudulent management practices, and an exaggerated confidence in the accuracy of the mathematical models. They assert that some actuaries did point at the uncertainties of their assessments, the lack of sufficient data and of modeling capacity, the problems of standardizing data in order to make comparisons and general assessments, and the difficulties in calculating an appropriate price (for example: Wemmer 2008, 1 et seq.). If these self-critical voices would have been heard, some dimensions of the crisis might have been prevented (Föllmer 2009; Donnelly and Embrechts 2010; for an early cautious voice: Bühlmann 1998, 174-6). Embrechts also concedes that the reliability of mathematical models has been overestimated and that the issue of "model uncertainty" is still not properly understood and needs to be dealt with more deeply in future actuarial research. Such calls for more detailed analyses of the mechanics of securitization have become a common theme in the post-crisis literature (Das, Embrechts and Fasen 2012; Cummins 2009, 477). However, most of these self-



critical voices only emerged during or after the crisis. Clearly, the normative effects of mathematical and actuarial expertise in constructing and legitimating new forms of market transactions, and in transforming capitalism as a whole, have clearly been underestimated by the actors (Orléan 2014, 318-20). However, that investors and the public put so much confidence into the accuracy of the mathematical models was not just the fault of the model constructors. The problem lies also with the rating agencies. Their negligent policies of warranting high credit ratings for asset-backed securities despite their lack of transparency was an important factor to foster the general belief in the mathematics underlying securitization (Orléan 2014, 264-71; Lybeck 2011, 141 et seq.; Hill 1996, 1076).

The answer to the other question of whether securitization in general is a tainted form of developing financial products can be derived from the development of the markets. There is much evidence that securitization is here to stay and will also expand in the future, despite the setback and the dubious reputation it gained during the crisis. Most market observers agree on this positive assessment. Inspired by the rhetoric of the presidential election campaign, Morton Lane, a prominent mentor of insurance-related securitization, argued that the new investment forms were “a change we believe in” (Lane and Beckwith 2009; see also: Albertazzi et al. 2011; Cummins 2009, 463 et seq.; Wemmer 2009).

The development of the markets, at least in the U.S., endorses this view. Currently, in 2014/15, the markets are not far away from where they stood before the crisis. The issuance of asset-backed securities in the U.S. reached 225 billion dollars (2014), close to the all-time high of 289 billion dollars in 2007. And the U.S. market for mortgage-backed securities reached issuance of 850 billion dollars for the first half of 2015, with a clear growth tendency against 2014 – compared to the all-time high of 2,692 billion dollars (for the whole of 2005). Only in Europe has securitization not recovered from the breakdown of the market in 2008. Issuances in the securitization market reached highs in 2007 and 2008 (819 and 1,210 billion dollars respectively), but are still clearly below 300 billion dollars in 2013 and 2014 (SIFMA 2015). In insurance, for example, the market for Cat bonds has recovered from the crisis, reaching a value of 23 billion dollars in 2014; that is about 10 per cent of the global market for non-life reinsurance. Even a mega catastrophe like the nuclear disaster of Fukushima in 2011 only produced a temporary decline of the Cat bonds market. Similarly, though on a much smaller level, markets in life insurance securitization are growing again (Swiss Re 2013; Philips 2014; Cummins 2009, 485 et seq.).

The recovery of securitization counts even more as the regulatory policies after the 2007 crisis has identified securitization as an operational risk for financial institutions and has strengthened the regulatory expectations against the process, especially in the context of Basel III, for which the first draft was

published in 2010 and which was introduced in the European Union in 2014, and the insurance related Solvency II, published in 2009 (Lybeck 2011, 274-9; Baig and Choudhry 2013, 33 et seq.).

The growing confidence of the market is also reflected in recent discussions of new growth areas for securitization, for example in the insurance of nuclear risks. The Fukushima catastrophe put the question of how to insure the risks of nuclear catastrophes under the spotlight. The arguments are still cautious. But some observers, such as the French economist and insurance specialist Pierre Picard, argue that, despite technical difficulties, there was no fundamental obstacle to transferring large-scale nuclear risks to the financial markets. According to Picard, the main problem for securitizing nuclear risks lies with defining their price. Damages from nuclear accidents are extremely expensive, and their long-term consequences, often over decades, make it difficult to calculate their exact costs. That is the reason why currently nuclear risks are only partially covered by the insurance industry, mostly up to a certain amount of damage. The state is covering the remaining risk as an insurer of last resort. But Picard and others argue that the instrument of securitization allows the tapping into the vast resources of financial markets and that this could shift significantly the distribution of responsibility between the state and the private industry. They see nuclear risks as insurable and a market price even for large-scale nuclear risks as feasible (Picard 2011; Louaas and Picard 2015; more skeptically: Koletschka 2013, 138). Obviously, this would also change the logic of covering for the consequences of a nuclear disaster risk. At the moment, the responsibility for dealing with such disasters lies primarily with the state, the political authorities, and ultimately the citizens. In a world of securitization, dealing with nuclear disasters – at least paying for the damages – would become a commercial issue, dealt with by investors under the logics of the financial markets.

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## 5. Conclusion

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What conclusions can be drawn with respect to the larger social implications of the rise of securitization? What conventions were addressed in the context of securitization, and how has the setting of conventions changed since the 1970s? Three points should be highlighted. First, the history of securitization reveals important aspects of the emergence of financialized capitalism, notably a long-term shift in the social responsibilities and policies towards risks. The examples of mortgage credits, catastrophe risks, nuclear risks, or longevity and mortality risks all show a similar pattern. These risks were originally addressed – at least partly – within the logics of political or socio-political conventions, often with the state as an insurer of last resort or in the context of the welfare state. The trend towards securitization usually meant that the socio-political conventions

were replaced by financialized, market-oriented conventions, in which investors would take responsibilities, bear the risks, and eventually cash in the profits or pay the losses of the financial transactions. The settings of these two conventions are very different. The socio-political convention is part of the institutional logic of politics, ultimately of the community of citizens, whereas the financialized convention is based on an anonymous community of investors, driven by a bet on future profits.

Secondly, some of the examples, notably in the area of longevity risks and nuclear risks, show that the transformation from socio-political to financialized conventions often comes along with a privatization of formerly public responsibilities. In both cases, securitization is still at an early stage and it is not clear how transformative the future development will be. But the vision of advocates of securitization is clear: The state will lose some of its current responsibilities – in the pension system and the insurance of nuclear risks – and delegate them to the financial markets. A similar process takes place in the securitization of credit and insurance risks. Here, responsibilities are transferred between private actors. Private corporations like insurances and banks delegate their previous business to the actors of the financial markets.

Thirdly, the history of securitization clearly shows that mathematical and actuarial forms of expertise were driving forces for this trend. They acted as conventions of equivalence, making different forms of risks comparable and marketable. And with their normative authority, they increased the legitimacy of such transactions.

Finally, it is important to note that the spread of securitization is still an ongoing and dynamic process. It is too early to predict how far this process will actually go. Some questions will have to wait further for a final answer: Will Europe take the same path as the more securitization-friendly U.S.? And will mathematical calculus be ultimately an instrument to stabilize practices of securitization or will it continue provoking exaggerated confidence in a basically unstable technique?

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